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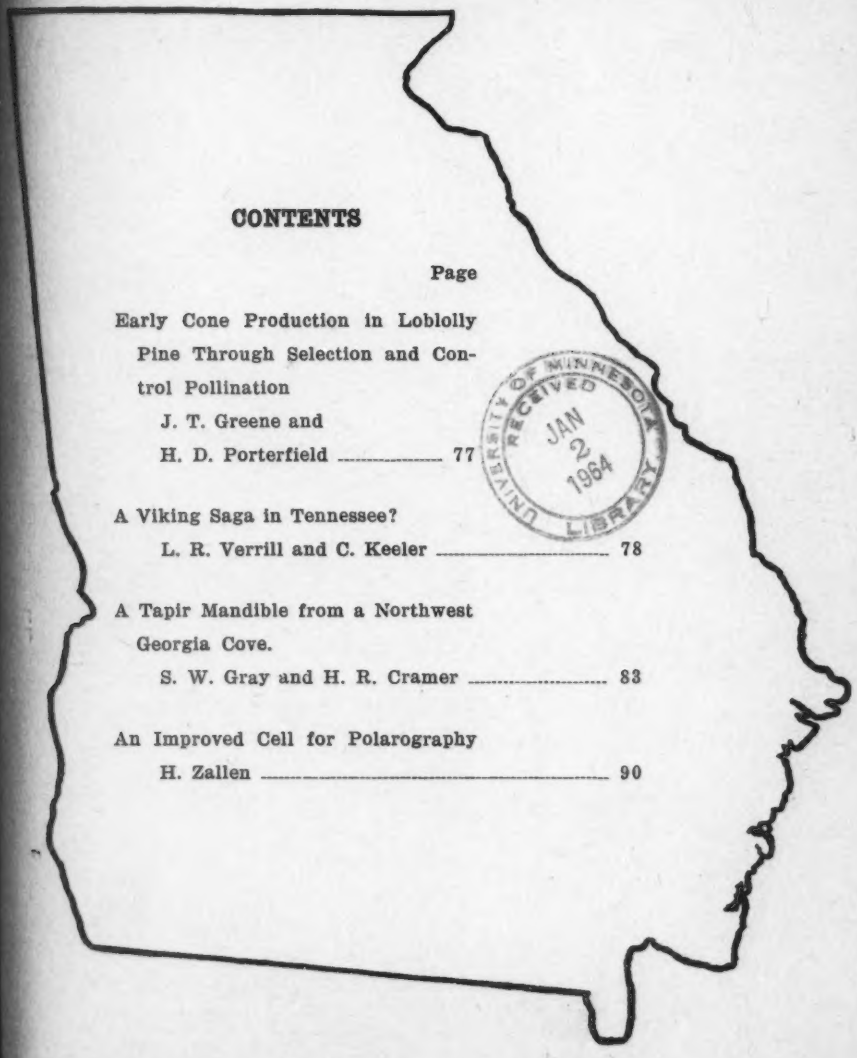

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EARLY CONE PRODUCTION IN LOBLOLLY PINE THROUGH SELECTION AND CONTROL-POLLINATION

JAMES T. GREENE and H. D. PORTERFIELD

University of Georgia

Under natural conditions loblolly pine (*Pinus taeda* L.) trees ordinarily begin to "flower" at about 10 to 15 years. However, Weddell (1935) reported the production of cones with viable seed for 7-year-old loblolly pine. Righter (1939) reported the average of the minimum ages of ovulate flower production for 55 species and varieties of pine to be 5.2 years. The earliest reported ages of flower production in loblolly pine were 5 years for ovulate flowers and 6 years for staminate flowers. Hoekstra and Mergen (1957) reported the stimulation of early flowering on 6-year-old slash pine (*Pinus elliottii Engelm.*) trees by root-pruning, stem-injury and fertilization. Reines and Greene (1958) located a 21-year-old loblolly pine on the property of the University of Georgia bearing seed which produced seedlings that had mature cones at 4 years of age. A total of three seedlings under this particular phenotype were observed to produce female flowers in March, 1956. Two conelets were controlled pollinated, but were broken off by birds. One open-pollinated conelet matured and was collected in 1957. The cone was mature in all respects and yielded 77 normal seeds. The seeds produced 55 healthy and normal seedlings from the 77 seeds, a total of 72 percent. After three years in the field, 50 of these seedlings are healthy and normal.

Other selected loblolly pines ranging from 21 to 30 years of age are yielding seed that produce "seedlings" which bear female strobili at 3 to 4 years from seed. One 3-year-old loblolly pine (L-81A) "seedling" produced female strobili in 1959, after 2 years in the field. These strobili were backcrossed to one of the original parents Two cones from this cross were collected in late 1960. The cones yielded 102 normal seeds. These seeds produced 44 normal seedlings from the 102 seeds, a total of 43 percent. The seedlings are now potted and growing at the school nursery. This same "seedling" produced three female strobili in 1960 which were backcrossed again to one of the original parents. This seedling has produced female strobili for three consecutive years. The authors believe that this is the first report of a successful cross with seedlings of this age in southern pines. Open-pollinated seeds from other 3-to 4-year-old loblolly seedlings are now in storage.

An opportunity for reducing age of flowering in loblolly pine exists in the selection of early-flowering phenotypes like the ones just described. These phenotypes can be crossed with other genotypes to create new early-flowering varieties with desired characteristics.

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A VIKING SAGA IN TENNESSEE?

L. Ruth Verrill
Chiefland, Florida
and
Clyde Keeler
Milledgeville, Georgia

The so-called Thruston Tablet (Fig. 1) was found with other relics near stone graves, mounds, and earthworks at Catalian Springs, beside

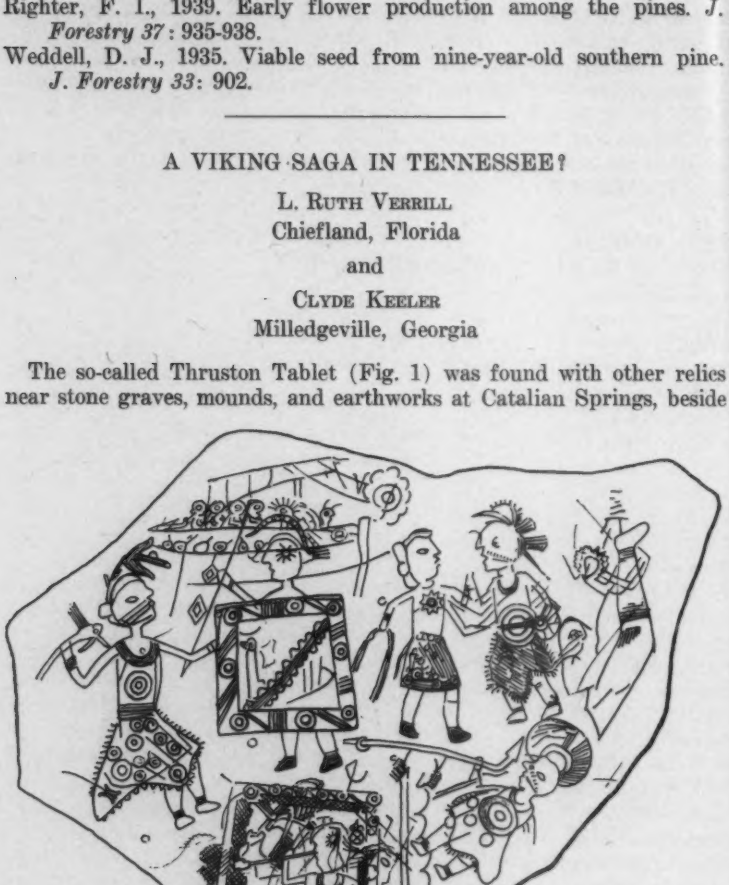

Fig. 1. *The Thruston Tablet.*

Rocky Creek, Sumner County, Tennessee. Although it was discovered about 1874, it is very little known today. From the time of its presentation to the Tennessee Historical Society twelve years elapsed before it was placed on exhibit at what was then the new Historical Rooms of Watkins' Institute, Nashville, Tennessee. From the first, this tablet has been considered very ancient and a genuine relic, but a truly critical study of it appears never to have been made. The slab is an unevenly surfaced, irregularly-shaped piece of limestone about 19 inches long and 15 inches wide, having all appearances of great age. A photograph of it may have been published first in the TENTH ANNUAL REPORT of the Smithsonian Institution, Bureau of American Ethnology, 1888-1889 and published in 1893, although it was described in 1890 by Gates P. Thruston in his book, ANTIQUITIES OF TENNESSEE.

In 1897 Thurston, in his second edition of ANTIQUITIES OF TENNESSEE, pages 88 to 97, tells of its finding and his interpretation of it. He says: "It was well and deeply graven, probably with some implement of quartz or flint upon the softer limestone's surface." The engraving depicts in considerable detail what must have been a highly important event. It seems to represent a surprise attack on the temporary camp of the ray-eyed ones at Rocky Creek by almond-eyed aborigines who came from over a chain of low hills or mountains (represented by four vertical scallops at the back of what we take to be a small medicine-lodge). The attackers are not ray-eyed. Their faces are painted. Their leader has four lines on his cheek, a custom common to certain tribes of Tennessee and Arkansas, while the others have one horizontal line with a number of short vertical lines extending above it. Each native wears a gorget and sun-disk. Their skirts are of animal skins. One has the fur on the outside and two have the fur inside, the latter type permitting the skin side to be decorated with circular patterns. The aboriginal leader at the left has in his right hand an axe (Fig. 2) like those of copper found in the Spiro Burial Mound, Spiro, Oklahoma, illustrated and described by the Museum of the American Indian, Heye Foundation, New York, in CONTRIBUTIONS FROM THE MUSEUM OF THE AMERICAN INDIAN, HEYE FOUNDATION, VOL. XIV. THE SPIRO MOUND COLLECTION IN THE MUSEUM by E. K. Burnett. HISTORICAL SKETCH OF THE SPIRO MOUND by Forrest E. Clements, New York, 1945, Plate LXXI. The head of the axe has the shape of a rabbit's head. The aboriginals wear ankle and wrist bands but do not have moccasins. Their headdresses are elaborate. The fourth figure to the right has at his back the severed head of a ray-eyed person. The eye is closed in death. Above the head the bleeding heart of the victim can be seen near the bound ankles; the soles of the feet being upward. The knees of the dead are also bound. The bleeding torso is probably suspended in the engraving. The mutilation of the dead person indicates the nature of the cult followed by the natives.

Another head is faintly discernable beneath the engraving thought

to represent a medicine-lodge. A spear, that must have had a metal head (for it is bent to a forty-five degree angle), lies on the ground above and to the right of the little medicine-lodge. Spearheads of this type were used by the Vikings, some having unusually long shanks. In THE VIKINGS by Johannes Bronsfed, published by Cox and Wyman, London, 1960 (Penguin Book), plate 2, spearheads of this type are shown. The bearer of a huge square object is obviously the leader of the ray-eyed ones. The position of legs and shod feet indicate that the square object is a shield, being held in a defensive position. On this individual's head is a Phrygian or Roman-type helmet (Fig. 3) with its large crescent-shaped crest. He wears shoes. The native leader is threatening him with an axe, and the ray-eyed one fearlessly defends himself with his spear and shield. The shield is not of an American type in shape or in decoration. It is possible that the design on the shield is significant, for it could represent a log stockade about a cleared area in which diagonally runs from corner to a crenulated vallum or earthwords. Perhaps the bearer of the shield is the Holder-of-the-Fort.

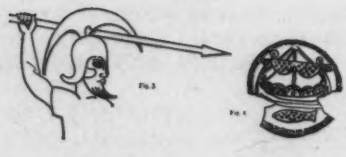

FIG. 2. *Copper-bladed axe from the Spiro Mound.*
FIG. 3. *Phrygian helmet with crescent-shaped crest. After Perrot and Chipiez.*
FIG. 4. *Viking ship displaying its shields. Coin found at Spangereid, Vest-Agden.*
FIG. 5. *Viking ship of old style with beak, having oval-bladed paddles. Rock carving from Brandeskog.*
FIG. 6. *Fourteenth century boat with stern rudder after the mural in Siljan Church, Telemark.*

In the book VIKING SHIPS by Broger & Stretetig, Morgensen & Company, Los Angeles, 1960, page 250, it is noted that the Normans had rectangular shields, and the round ones carried at the ships' rail in Viking pictures were placed there mainly for show when leaving or entering port (Fig. 4). To the right of the ray-eyed leader is a figure to be that of an almond-eyed Indian female. The hair is secured in an elongated bun, a type of hair styling seen on a pottery head from ancient earthworks near Hickman, Tennessee, and engraved on shell gorgets from stone graves. There are also representations of persons wearing this type of bun from other parts of Tennessee. See ABORIGINAL REMAINS OF TENNESSEE by Dr. Chas. C. Jones, page 63. She wears no face paint, has a fabric skirt and neat shoes. In her right hand she holds what may be a wampum belt, an offering of peace. However, a sling may be intended because the duplicated

arms of her attacker and herself could indicate a struggle. Here we may have a counterpart of Cortes' mistress, Marina.

At the lower end of the engraved scene is shown what we think to be a small, windowless, matting-lined medicine-lodge with one doorway. The frame is of small logs or poles lashed and secured by vines or rope-like roots. The little room is of a size for squatting or kneeling, as the kneeling figure shows. Many Amerindian tribes had such small medicine-lodges or shrines. The sketch of a small medicine-lodge of this sort has been published in the Bulletin of Georgia Academy of Science, 17:139, 1959.

The kneeling figure is a ray-eyed person who may be female because the hair is long and well-kept. The features are soft and there is no headdress. The rayed-eye is looking upward as if appealing in prayer to her deity. She wears no ornaments and her hair is not done up. This could indicate mourning in humility. Do these rayed-eyes denote eyelashes which are more obvious on fairer persons or do they indicate that the eyes are light in color (blue or gray)? We cannot say.

The kneeling figure is wrapped in fabric from the waist to about the knees. The pipe being smoked is common archaeologically to Tennessee. Smoking in early times was a ritual, a ceremony, part of ancient cults among many Amerindian tribes and not the general habit as it now has become. At the upper part of the engraving is carved, in surprising and accurate detail, a Viking-type boat of a style that was in use from around 800 to 1,000 A.D. that seems to have escaped notice up to the present. The figurehead is well drawn. At the base in back is the deep notch where a steering oar was used. The ropes supporting the mast and yard arm run to the figurehead at the bow and are in their proper positions.

The stem of the boat is distinctly European and not Amerindian. It is of correct proportion and shape and is like that of the Nydam boat in Slisvig from the fourth century, A.D. The figurehead is similar to that of the Oseberg boat. The Viking-type single mast and yard arm carry the sail. Their position and the pattern of the boat are features comparable to those of boats used by North European traders, explorers and colonizers up to about 1200 A.D. Such ships are represented on ancient Swedish coins (Fig. 4). The sail is made of six vertical strips of hand-loom material. Each strip would be from about 27 inches to 36 inches wide. This would mean that the sail was about 18 feet wide. This is a normal width for the sail of such a craft. A hauser-hole is discernible just back of the notch for the steering oar. This is comparable with its position on the Oseberg boat.

The boat's commander stands at the prow, wearing a pair of the familiar Viking horns, denoting his leadership. The "BISON," Norway's most famous Viking ship, carried oarsmen who wore Gallic-type helmets. There could have been about 20 oarsmen on a boat such as that shown in the engraving, and here five of them depicted as seated at the rowing level. The paddle ends of their oars are round or oval like those in the supposed iron-age Viking rock carvings of a boat

at Brandskog (Fig. 5), Uppland, Sweden. In both boats, the oar holes are at floor level as are those of the Oseberg boat.

Midway of the boat in the engraving can be seen a grappling or landing hook which would be of hard metal. To the left of this is a diamond-shaped fender of sennett-work, suspended from the boat's rail. It is mirrored in the calm water of the creek. Toward the stern a mooring line extends into the water. At the stern is clearly outlined an anchor of a well-known type that Vikings made out of granite and oak wood, at least in certain instances. See ARCHAEOLOGY, Winter 1960, Vol. 13, No. 4, page 227. NEW LIGHT ON VIKING TRADE IN NORWAY, by Charlotte Blindheim. The Kaupang boat anchor is of granite and oak, styled like that shown on the boat in the Tennessee engraving. Kaupang farms are near Larvik, County Vestfold, and not far from the famous royal Viking burial ship of Oseberg. The boat burials at Kaupang dated about 800 A.D. to 950, which affords a possible dating for the boat shown on the Thruston Tablet because several features are comparable. The boat's stern is squared and a tiller appears to be represented. This type of stern (Fig. 6) replaced the earlier pointed type at a period shortly after 1180 A.D. There seem to be a few brief inscriptions. That on the ray-eyed leader's shield may be his identification (Fig. 7). Just above the medicine-lodge at the right are glyphs that could give the name of the supposed female with the bun-style hair arrangement (Fig. 8). Back of the head of the figure in the medicine-lodge is a single glyph (Fig. 9).

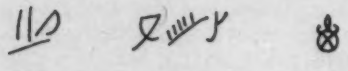

Fig. 7 Fig. 8 Fig. 9

FIG. 7. *Glyphs on Thruston Tablet.*
FIG. 8. *Glyphs on Thruston Tablet.*
FIG. 9. *Glyphs on Thruston Tablet.*

It may be of interest to note that the southern boundry of Sumner County, Tennessee, is formed by the Cumberland River that flows into the Ohio. This, in turn, empties into the Mississippi River at Cairo, Illinois. Thus, such a boat could have entered the Gulf of Mexico and sailed via the Mississippi River, the Ohio River, the Cumberland River, and Rock Creek to Castalian Springs, where the so-called Thruston Tablet was found.

ACKNOWLEDGMENT

The authors are grateful to Mr. Frank H. Roberts, Jr., Director of the Bureau of American Ethnology, Smithsonian Institution, for permission to publish a drawing of the Thruston Tablet, traced from the photo in the Tenth Annual Report of the Smithsonian Institution.

A TAPIR MANDIBLE FROM A NORTHWEST GEORGIA CAVE*

STEPHEN WOOD GRAY and HOWARD ROSS CRAMER
Emory University

Of the large mammals which roamed the southeastern Pleistocene forests, the tapirs are among the most unusual and among the least represented fossils. This may be due to the fact that they were forest browsers, a type of existence which is not conducive to fossilization. Hence, any new occurrence, such as this one, is of interest.

The specimen comes from Anderson Spring Cave, in Walker County. It was found by Mr. Gerald Kemper in 1955 (Hitchcock, 1957). The original is deposited in the Harvard Museum of Comparative Zoology, and a cast is at Emory University.

PALEONTOLOGY

The Specimen

The specimen is a portion of the left mandible of a tapir. Only the mid-portion of the mandible, including the beginning of the ascending ramus and five cheek teeth, is present (Fig. 1). The teeth are all of the permanent dentition, the last two molors being little worn.

FIG. 1. *Lateral aspect of portion of left mandible of Tapir from Anderson Spring Cave, Ga.*

The fragment is 168 mm. long and the depth of the mandible at the level of the first molar is 54 mm.

*Presented at the Southeastern Section meeting of the Geological Society of America, Knoxville, Tennessee, April, 1961.

TABLE 1

Measurements of Grinding Teeth of Tapir Mandible from Anderson Springs Cave, Georgia

	Length	*Width of Anterior Lobe*	*Width of Posterior Lobe*
	(mm.)	(mm.)	(mm.)
M_3	23.5	19.5	17.5
M_2	21.5	18.5	17.5
M_1	20.5	17.5	15.5
PM_4	20.0	16.0	16.0
PM_3	18.5	13.0	14.0
PM_2	missing		

An X-ray of the jaw (Fig. 2), shows no unerupted teeth, and shows complete root formations of the erupted teeth. The animal was fully adult but not senescent.

The specimen is closest to *Tapirus veroensis* Sellards 1918, which

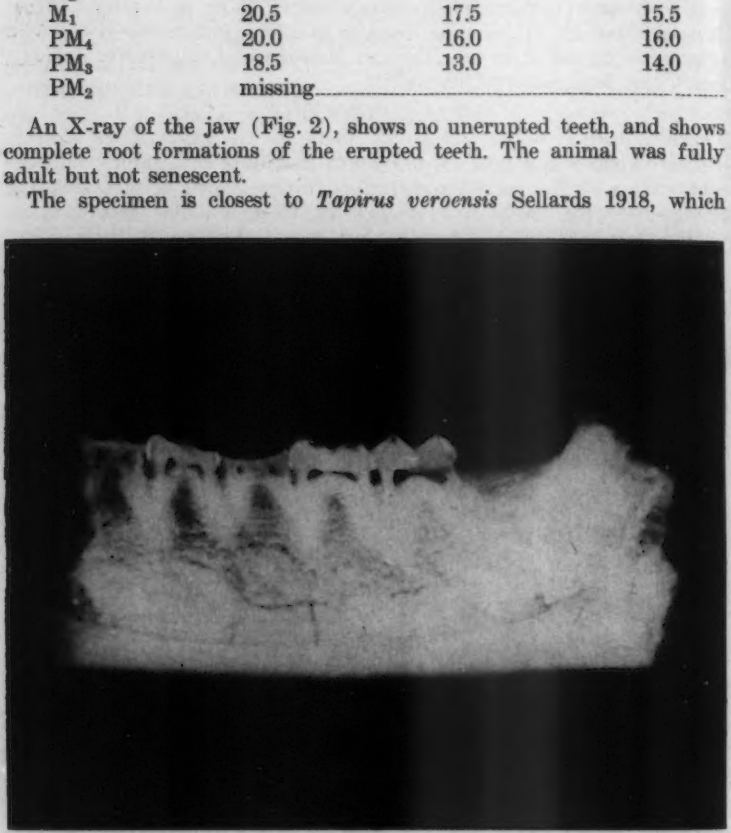

FIG. 2. *Radiograph of Tapir mandible. Note that permanent dentition is fully developed.*

is known from several Pleistocene localities in Florida and perhaps from Tennessee (Simpson, 1945). Identification was made by Dr.

Bryan Patterson of the Museum of Comparative Zoology at Harvard, based on the dental measurements in Simpson's review.

Preservation

Mineralization is extensive but not complete (Fig. 2). The inner surface shows cracks indicative of weathering for a short time before preservation. There are no tooth marks of gnawing rodents, and it is the authors' feeling that the fractures at either end occurred prior to mineralization. There are no indications of tooth marks, but this does not prevent the possibility that the tapir was dragged into the cave by a large predator. Other possibilities include accidentally falling into the cave from a hole at the surface and secondary erosion and transportation of the specimen by subsurface water after initial deposition. No great distance or time could have been involved in the latter case, as no water wearing is evident.

The conditions under which the specimen was found are nebulous. The specimen was found "strewn on the floor of the cave" (Hitchcock, 1957). No other vertebrate fragments are reported associated with it. The cave is now used as a source of water for the owner's farm and is closed to further exploration.

Age of the specimen

While one cannot be certain, the age of the mandible is most likely to be Pleistocene. Brown (1938) and Hurst (1957) report tapir fragments from Pleistocene beds in Louisiana and Georgia, and Sellards (1918) reports this particular species from the Pleistocene sediments at Vero, Florida. This species is not known from the Pliocene, and had become extinct by recent time.

Climatological data

Brown (1938) and Berry (1907a and b, 1926) both conclude from paleobotanical evidence that the Pleistocene temperatures and flora were much the same as they are now. Berry (1907a) lists the following species from a Pleistocene peat bog on the Chattahoochee River, 165 miles south of the cave.

Carpinus caroliniana Walter	*Quercus phellos* Linnaeus
Betula nigra Linnaeus	*Ulmus alata* Michaux
Fagus americana Sweet	*Liriodendron tulipifera* Linnaeus
Quercus nigra Linnaeus	*Platanus occidentalis* Linnaeus
Q. virginiana Mill	*Ilex opaca* Ait.
Q. primus Linnaeus	*Xolisma ligustrina* DC.

These are interpreted by Berry as being representative of "climatic conditions not appreciably different from those which exist at the present time in this region, although the grouping of the species was quite different from that which obtains in the present Gulf coast." If these interpretations are correct, it would seem that this Georgia tapir lived in a forest environment such as exists in the area today. According to Harper (1918) the forests of Alabama, only a few miles away, were originally "splendid forests of long-leaf pine, intermingled with various oaks and a small proportion of short-leaf pine."

The mammalian fauna would not be so familiar. A number of now extinct large animals shared the southeastern forests with the tapir in the Pleistocene. Mastodons, Columbian Elephants (*Paralephas*) and giant ground sloths browsed in the forests with the shyer, and probably even then, nocturnal tapirs. Peccaries competed for bulbs and roots. Chief among the tapir's enemies were probably bears, wolves, the direwolves (*Canis ayersi*), and a number of large cats. Bison, camels and horses grazed where grassland existed. Hurst (1957) gives an interesting account of the southeastern fauna with illustrations of many of the larger mammals.

FOSSIL TAPIR DISTRIBUTION IN THE UNITED STATES

Simpson (1945) gives a splendid summary of Pleistocene and recent tapirs and includes a map showing all of the then known locations. They range from Pennsylvania to Florida, west to Missouri, Arkansas and east Texas. There are two localities known near the Mexican border and a number in California. Most of the greater number of finds have been in the eastern states, however, associated with the mixed mesophytic forests of the same.

Several locations are known from Florida, from which the type *Tapirus vercensis* Sellards comes. A specimen of *T. tennesseae* Hay (= *T. veroensis*) comes from eastern Tennessee. The closest known tapir find to the specimen reported here comes from Lookout Cave, Tennessee. It is reported but not described by Cope (1899).

Other tapir remains from Georgia are from the Coastal Plain, near Brunswick and Savannah. At Brunswick, bones of a number of Pleistocene mammals, including tapir fragments, were unearthed from an old lake bed during the construction of the Brunswick and Altamaha canal in 1839. Hay (1923) has described this material as well as subsequent discoveries in the same location and at Savannah. Hurst (1957) gives a popular account of the tapir and other mammals from these areas. None of the remains are of the complete animals.

DESCRIPTION AND HISTORY OF TAPIRS

Tapirs are stout animals about 6 feet in length and standing about 4 feet at the withers. American species are dark brown with pale throat and ear tips. The young are spotted and longitudinally striped like fawns. Their most striking character is the foot-long, flexible, upper lip, resembling a miniature trunk of an elephant.

Modern tapirs are solitary, nocturnal, and generally inoffensive. They take to water readily (Fig. 3). Shoots, buds, leaves and low-growing fruits form their food. The similarity of the habits of existing species suggests that their behavior has changed little since the Pleistocene. They are eaten by natives, and their thick hide makes tough leather. They are said to be easily tamed.

Anatomy

Characteristic features of tapirs are the presence of four toes with hoofs on the front and three on the hind foot. The ulna and the fibula

FIG. 3. *Living American Tapir, Barro Colorado, Canal Zone. Courtesy of the American Museum of Natural History.*

are complete and not fused with the radius or the tibia, unlike the condition in the Equidae. There is far less change from the primitive perissodactyl condition in their group than among the horses or rhinoceroses.

Teeth are the most readily preserved parts of the body, and are therefore of the greatest paleontological importance. Three incisors are present in each side of each jaw. The canine is well developed rather than being lost as in other perissodactyls. There is a short space or diastema between the canines and the battery of cheek teeth which consists of four premolors and three molars in the maxilla and three molars in the mandible. Molarization of the premolars has taken place as is usual in the Perissodactyla, and there is no functional distinction between molars and premolars.

In the mandible, the first premolar is rudimentary or lost. P_{2-4} and M_{1-3} make up the grinding battery. The upper cheek teeth are often simply lophodont, but the mandibular set have characteristic transverse crests. This pattern is in contrast to the complex arrangement of ridges found in equid teeth. Tapir molars and premolars are easily distinguished from teeth of other mammals.

The anterior premolar, canine and incisors, are missing in the present specimen, but we have indicated their appearance in Figure 4.

Taxonomy

FIG. 4. *Outline of Tapir mandible, preserved portion of present specimen shaded.*

The tapirs, rhinoceroses and horses are the three living branches of the once great group of perissodactyl ungulates:

Perissodactyla
- tapiromorphs
  - tapirs
  - rhinoceroses
- hippomorphs
  - horses and their allies
  - (titaanotheres) up to Oligocene
  - (chalicotheres) up to Pleistocene

Tapirs (*Protapirus*) first appear in the Oligocene, having probably developed from a group of Eocene "lophiodonts" such as *Homogalax*, *Lophiodon*, and *Heptodon*. They occupied the North Temperate Zone of both Old and New Worlds by Pleistocene time with few anatomical changes. Despite their existence since the Oligocene over most of the Northern Hemisphere, tapirs have not shown much anatomical lability. All New World Pleistocene and recent forms may be placed in a single genus. There is little to distinguish even Miocene and Pliocene forms from Pleistocene and living species. During the late Pleistocene they became extinct over most of their great range. Either the Wisconsin or the Illinoian glacial advance drove them southward from North America, although some may have survived into the post-Pleistocene and thus been contemporary with man. They now range from southern Mexico to Paraguay. In the Old World they were forced south even earlier, and are now restricted to Malaya, Sumatra and Borneo.

The Old World tapirs are represented by a single species, *Tapirus indicus* Desm. It was not discovered by Europeans until 1819. Cuvier

had stated that there was no longer any chance of discovering a large mammal unknown to science. In reply, a former student named Diard sent him from Bengal a sketch of a tapir! For relationships between this and American forms, the reader should consult Simpson (1945).

American tapirs were mentioned by travelers under the name "land hippopotamus" shortly after discovery of the New World, and designated *Hippopotamus terrestris* by Linnaeus in the 10th edition of the Systema Naturae, 1758.

Of American tapirs, four species are recognized at present. The best known is *Tapirus terrestris* Linnaeus. It ranges from Colombia to Matto Grosso and from eastern Peru to British Guiana. Some local races have been given specific names. *Tapirus roulini* Fischer is the smallest and least specialized of living tapirs. It lives in the Andes at altitudes over 8,000 feet. *Tapirus bairdii* Gill, and *Tapirus dowi* Gill, have been sometimes placed in a separate genus *Elasmognathus* Gill 1865 or *Tapirella* Palmer 1903. These species have elongated nasal septum. They occur in southern Mexico and parts of Central America. The Pleistocene tapirs in the United States have been placed in five reasonably well-defined species by Simpson. Numerous other specific names have been applied to fragmentary material and some may represent valid species when more is known of them. The following species seem well established.

Tapirus veroensis Sellards. The present specimen probably belongs here.

Tapirus copei Simpson. This includes the *T. haysii* of Cope from the Port Kennedy, Pa., deposits, not the original *T. haysii* of Leidy based upon a single tooth which should be referred to *T. veroensis.*

Tapirus excelsus Simpson.

Two other species occur on the west coast:

Tapirus californicus Merriam. A nominal species based upon a single tooth.

Tapirus merriami Frick. From California, this is the largest of Pleistocene tapirs.

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AN IMPROVED CELL FOR POLAROGRAPHY

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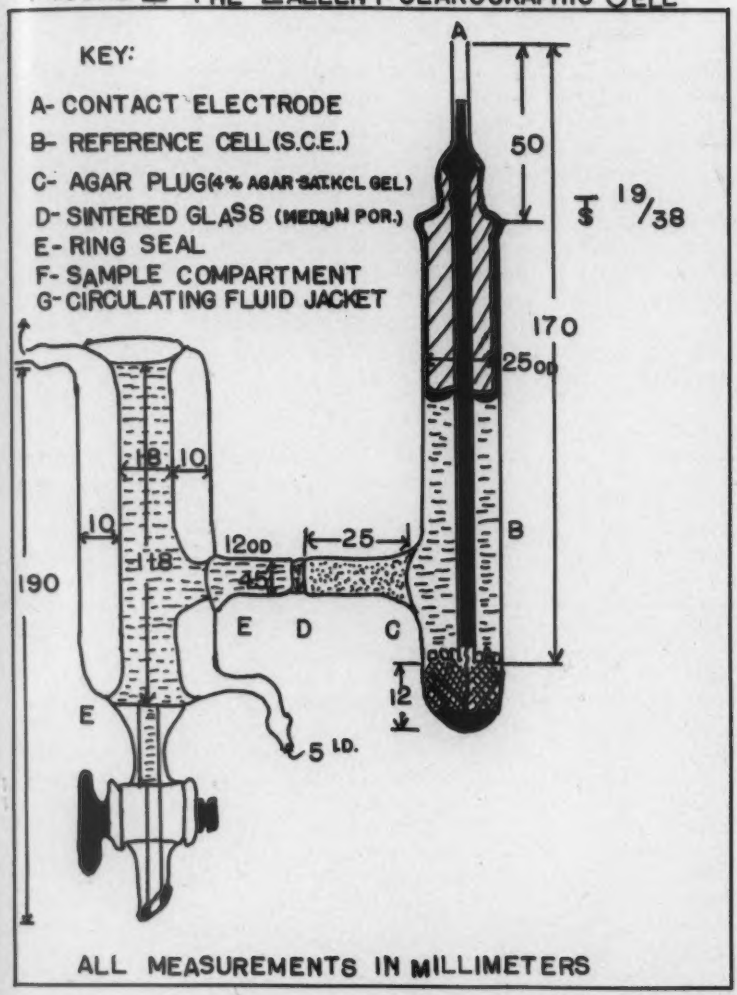
During the investigation of certain pharmaceutically active bis-beta-haloethylamine compounds (1) a new polarographic cell has been developed. The conventional H-cell of Lingane and Laitinen (2) caused contamination of the test solution by constituents of the reference electrode (chloride ion or agar). Carritt (3) recommended a modified cell which prevents this diffusion; however, this cell was found cumbersome to handle. Pecsock and Juvet (4) made further modifications by placing a reservoir compartment in the design for flushing the cell. The cell developed (Fig. 1) was found to be superior for kinetic studies. The placing of a sintered glass disk (D) 12 mm. from the test solution portion of the cell resulted in a cell which gave no discoloration or contamination of the agar plug. The cell was used for one year with constant use and no evidence of agar plug contamination, discoloration or drying out was witnessed. Cell samples were kept in contact with the bridge as long as 48 hours for prolonged kinetic studies. The circulating fluid packet (G) of the cell provided for constant temperature control during these studies. A Sargent Thermonitor Temperature Control Bath along with an Eastern Industries Model A-1 Electric Pump circulated the water through the jacket. When temperatures were used that exceeded the usual 25°, good control was still maintained. A stopcock was provided to empty the contents of the cell quickly. All solutions were degassed in a degassing flask prior to use. A rubber stopper was fitted on top of the test cell (F) to allow a constant flow of nitrogen to blanket the solution being electrolyzed. The i_R correction of a cell of this basic design with aqueous supporting electrolytes is reported to be less than 500 ohms by Lingane (5) and Meites (6) reports the i_R drop may be generally ignored. The resistance of the

FIGURE 1: THE ZALLEN POLAROGRAPHIC CELL



electrolytic cell, including the external reference electrode and connecting salt bridge was later substantiated as 350 ohms by use of a Conductivity Bridge (Model RC Industrial Instruments, Inc., Cedar Grove, N. J.). The cell is constructed of Pyrex Brand glass and has a minimum sample volume of 25 ml.

Figure 1. The Zallen Cell
A—Contact Electrode
B—Reference Cell (Saturated Calomel Electrode)
C—Agar Plug (4% Agar-Saturated KCI gel)
D—Sintered Glass Disk (medium porosity)
E—Ring Seal
F—Sample Compartment
G—Circulating Fluid Jacket
All measurements in mm.

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